ORIGINAL ARTICLE

Stress fractures of the femoral shaft in athletes: a new treatment algorithm

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Background: Femoral shaft stress fractures in athletes are not common but pose a great diagnostic challenge to clinicians. Because of few clinical signs, diagnosis and treatment are often delayed. Furthermore, if not treated correctly, these fractures are well known for complications and difficulties.
Objective: To develop a well structured and reproducible treatment algorithm for athletes with femoral shaft stress fractures.
Methods: The proposed algorithm is carried out in four phases, each lasting three weeks, and the move to the next phase is based on the result of the tests carried out at the end of the previous phase. Over nine years, we treated seven top level athletes, aged 17–21. In all athletes, diagnosis was based on physical examination, plain radiographs, and bone scan.
Results: As a result of the treatment method, all the athletes were fully engaged in athletic activity 12–18 weeks after the beginning of treatment. After completion of the treatment, the athletes were followed up for 48–96 months. During the follow up, there was no recurrence of discomfort or pain, and all the athletes eventually returned to competition level.
Conclusion: These results and data available from the literature suggest that the algorithm is the optimal treatment protocol for femoral shaft stress fractures in athletes, avoiding the common complications and difficulties.

Stress fractures are overuse injuries of bone, and may be defined as partial or complete fracture that results from repetitive application of stress of less strength than that required to fracture bone in a single load.[1] Imbalance between bone formation and resorption is a result of this excessive repetitive load.

Stress fractures constitute about 10% of all sport related injuries, and the most common site is the tibia.[2] Stress fractures of the femur are relatively uncommon, and data from the literature suggest that they constitute only 2.8–7% of all sport related stress fractures.[3–5] Nevertheless, they do pose a great challenge for both diagnosis and treatment.

This paper presents a new treatment algorithm for athletes with femoral shaft stress fractures. Using this tool, clinicians can treat these injuries in a uniform and structured manner and also compare outcomes in different institutions.

MATERIALS AND METHODS

Seven top level athletes (three long distance and four middle distance runners) were diagnosed with stress fracture of the femoral shaft and treated in our department during 1992–2001. Six were male and one was female, aged 17–21 years. The time from the occurrence of symptoms until they reported to our outpatient unit was one to eight weeks, but mostly two to four weeks.

The athletes' histories indicated that all had vague anterior thigh pain, especially during and after training sessions. During the physical examination, we used the hop test as described by Matheson *et al*[3] and the fulcrum test as described by Johnson *et al*,[6] both of which gave positive results in each of our patients. In the hop test, the patient attempts to hop on the injured leg, inevitably reproducing pain if an undisplaced stress fracture is present. For the fulcrum test, the athlete is seated on the examination table with lower legs dangling. The examiner's arm is used as a fulcrum under the thigh and is moved distal to proximal thigh as gentle pressure is applied to the dorsum of the knee with the opposite hand. At the point of fulcrum under the stress fracture, gentle pressure on the knee produces increased discomfort which is described by the patient as a sharp pain and is usually accompanied by apprehension. These tests are very sensitive and were also used during follow up to determine the eligibility of the patient for transfer to the next phase of the treatment. Both plain radiography and technetium bone scan were applied in all athletes (figs 1 and 2).

Figure 1 Anteroposterior and lateral roentgenograms showing stress fractures in the proximal third of the right femoral shaft (white arrow).

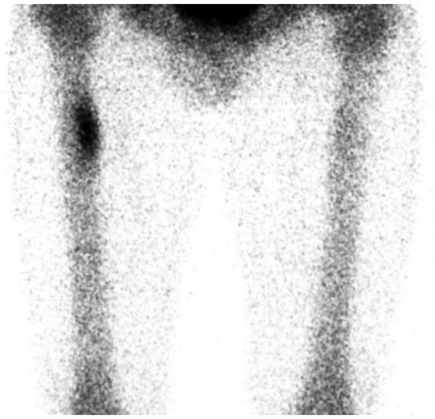

Figure 2 Technetium bone scan of the patient in fig 1.

The treatment was carried out in four phases, each lasting three weeks (fig 3). Transfer to the next phase was based on the result of tests (fulcrum and hop) carried out at the end of each respective phase. If the tests were positive after three weeks, the patient was returned to the beginning of that phase. In the first phase, which was called symptomatic, the athletes walked with the help of crutches and were instructed not to weight bear on the affected leg. In the second phase, called asymptomatic, normal walking was allowed. The patients started swimming in the pool and exercising in the gym (only the upper extremities and the unaffected leg). In the third phase, called the basic phase, the patients were allowed to perform exercises with both upper and lower extremities. They were instructed to use smaller weights, and were allowed to run in a straight line every other day, as well as to ride a stationary bicycle. The distance that they were allowed to run was gradually increased. During the fourth, so-called resuming, phase, with the coach's agreement, the athlete gradually started normal training.

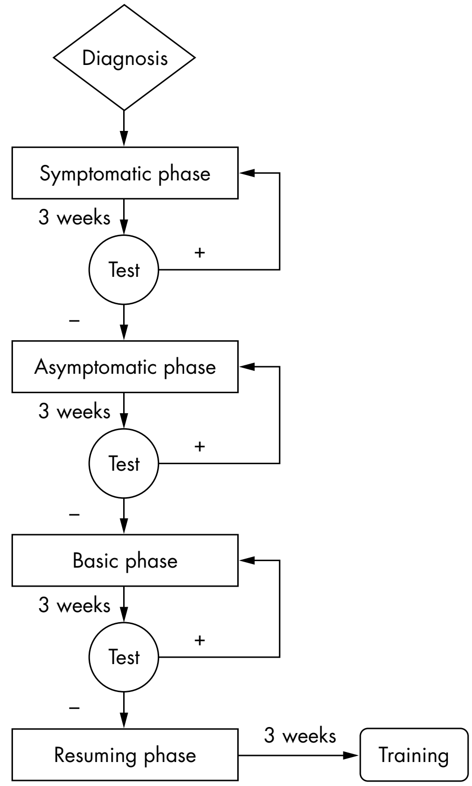

Figure 3 Four phase treatment algorithm for athletes with femoral shaft stress fractures.

RESULTS

As a result of being treated by this method, all the athletes were fully engaged in athletic activity 12–18 weeks after the beginning of treatment. After the treatment, the athletes were followed up for 48–96 months. During the follow up, there was no recurrence of discomfort or pain, and all athletes eventually returned to competition level. Table 1 summarises all the results.

DISCUSSION

There are two main groups in the general population that are very susceptible to femoral shaft stress fractures: athletes and military recruits.[7] The main difference between these two groups is that more than 50% of the fractures in military personnel are located in the distal femur (almost half of these are displaced), and most fractures in athletes are in the proximal femur.[6 8 9]

Stress fractures of the femoral shaft are not common but when they do occur it is usually in the proximal third of the femur.[10–14] It is a logical consequence of the tubular shape and bowed configuration of the femur. During dynamic stress—for example, running—the medial side is under compression and the lateral side is under tension, as revealed by Koch's free body analysis of the femur.[15] This analysis shows that the junction of the proximal and middle third of the femur in the subtrochanteric region is particularly susceptible to repetitive submaximal stress. Indeed this was the most common localisation in our series, but one should not overlook other possible locations such as the distal femur.

Information in a patient's history such as a sudden increase in mileage or intensity or frequency of training, a change in the running surface, or incorrect footwear should raise suspicion of a stress fracture. Other possible causative factors include having high arches or a supinated foot type, late age of onset of menarche, and low bone mineral content.[16–19] Patients usually present with vague, anterior

Table 1 Clinical data for the athletes with femoral shaft stress fractures

Case	Sex	Age	Sport	Delay in diagnosis (weeks)	Return to full sport (weeks)	Follow up (months)
1.	M	19	Runner (5000 m)	4	12	96
2.	M	21	Runner (5000 m)	2	12	94
3.	M	18	Runner (10 000 m)	1	12	89
4.	F	17	Runner (1500 m)	8	18	75
5.	M	19	Runner (3000 m)	2	12	52
6.	M	17	Runner (1500 m)	4	18	48
7.	M	19	Runner (1500 m)	2	12	48

What is already known on this topic

- Femoral shaft stress fractures are rare, difficult to diagnose, and, if not treated correctly, have high rates of recidivation and complications
- Several large series have been published in the literature, but none have addressed the issue of the treatment algorithm

What this study adds

- This study offers a well structured and reproducible treatment algorithm for athletes with femoral shaft stress fractures
- It was designed in accordance with the special demands of a high level athlete, and, if conducted properly, it prevents detraining and enables quick return to training without recidivation

thigh pain and few physical findings. The hop and fulcrum tests are positive during the physical examination. Standard radiographs are always obtained, although at the time of symptom onset they are positive in only 30–70% of cases.[3 4 20] The diagnosis is confirmed by either bone scan or magnetic resonance imaging (MRI). Triple phase technetium-99 m bone scan is the optimum method for diagnosing stress fracture, and for correct diagnosis all three phases must be positive.[19] MRI is used to differentiate stress fractures from other pathological processes, especially neoplastic ones.[21] In the case of stress fractures of the femoral diaphysis, MRI shows periosteal oedema as well as bone marrow oedema which usually involves the posteromedial aspect of the femur near the junction of the proximal and middle thirds.[22] Axial T2 weighted images usually show the pathomorphology best. Compared with bone scan, MRI has a similar sensitivity but an improved specificity, and is becoming the diagnostic procedure of choice. At this point we would like to stress the importance of early diagnosis, because we have noticed that athletes with a delayed diagnosis take longer to return to full training (cases 4 and 6 in table 1).

The main treatment for femoral shaft stress fractures is rest from the offending athletic activity, a concept known as "relative rest".[4 10 23 24] Furthermore, if not treated correctly, femoral shaft stress fractures are well known for complications and difficulties, such as delayed healing, fracture displacement, and symptom recurrence. Taking into account these two facts, we constructed the four phase treatment algorithm for athletes with femoral shaft stress fractures. If conducted as described above, it allows bone to heal but avoids detraining of the affected athlete. General conditioning is maintained by exercising other areas of the body and doing alternative training, such as water running, swimming, or cycling. Nevertheless, the athlete returning to proper training must be cautioned to resume at a frequency and intensity well bellow the level that produced the symptoms. The duration of treatment may vary according to the individual patient, but it is reasonable to expect that, for most with stress fractures of the femur, the period of relative rest will last 12 weeks. Compliance is critical to the success of the treatment, as well as good cooperation between the treating physician, athlete, and coach.

On the basis of our experience and available data from the literature, we conclude that this four phase algorithm is the optimal treatment protocol for athletes with femoral shaft stress fractures, to avoid the common complications and difficulties.

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COMMENTARY

Stress fractures of the femur are rare in athletes. When they do occur, they present a diagnostic and therapeutic challenge. This paper presents a very practical treatment algorithm which enables a safe return to sport. For diagnosis, the value of bone scans is highlighted. With its increased availability, in my opinion magnetic resonance imaging is now playing a more important role. As a doctor who takes care of high level athletes, my awareness of the problem was raised and I was provided with an added important differential diagnosis in cases of thigh and adductor muscle pain.

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